Background under Upsilon peak in central Au+Au collisions in sPHENIX

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Code in cvs: offline/analysis/sPHENIX/Quarkonia_BG
Technical note:
https://www.phenix.bnl.gov/WWW/p/draft/lebedev/sPHENIX/upsilon_background.pdf

Introduction

We consider two kinds of background:

Correlated background from charm, bottom and Drell-Yan.

Combinatorial background from mis-identified hadrons and their combinations with single charm/bottom electrons.

Not included: correlations from jets. But in central Au+Au back-to-back jets are suppressed. Studying this right now.

We calculate background for 10B 0-10% central Au+Au events.
We use $p_T>2GeV/c$ cut, which does not affect Upsilons.
$p_T>3GeV/c$ cut kills ~15% of all Upsions.

Correlated charm/bottom background

Main assumption: with 2GeV/c p_T cut there is no more than one correlated electron-positron pair per event even in central Au+Au events.
This is confirmed by simulation.

Thus, we can use tuned PYTHIA and scale it to central Au+Au collisions.

1. Generate p_T and invariant mass distributions using tuned PYTHIA
2. Normalize p_T distribution from PYTHIA to measured charm/bottom p_T distributions in Au+Au

HF electrons in Au+Au [PRL 98 172301 (2007)] are separated into charm and bottom using measured (ppg094) charm/bottom ratio in p+p.
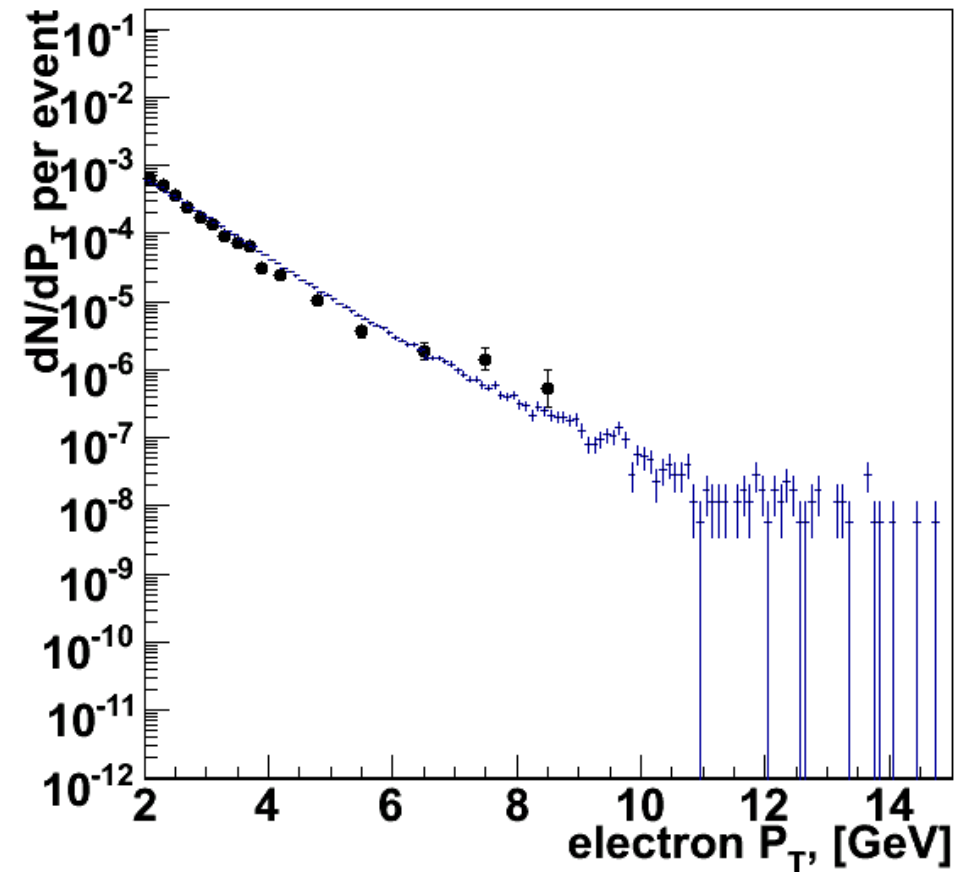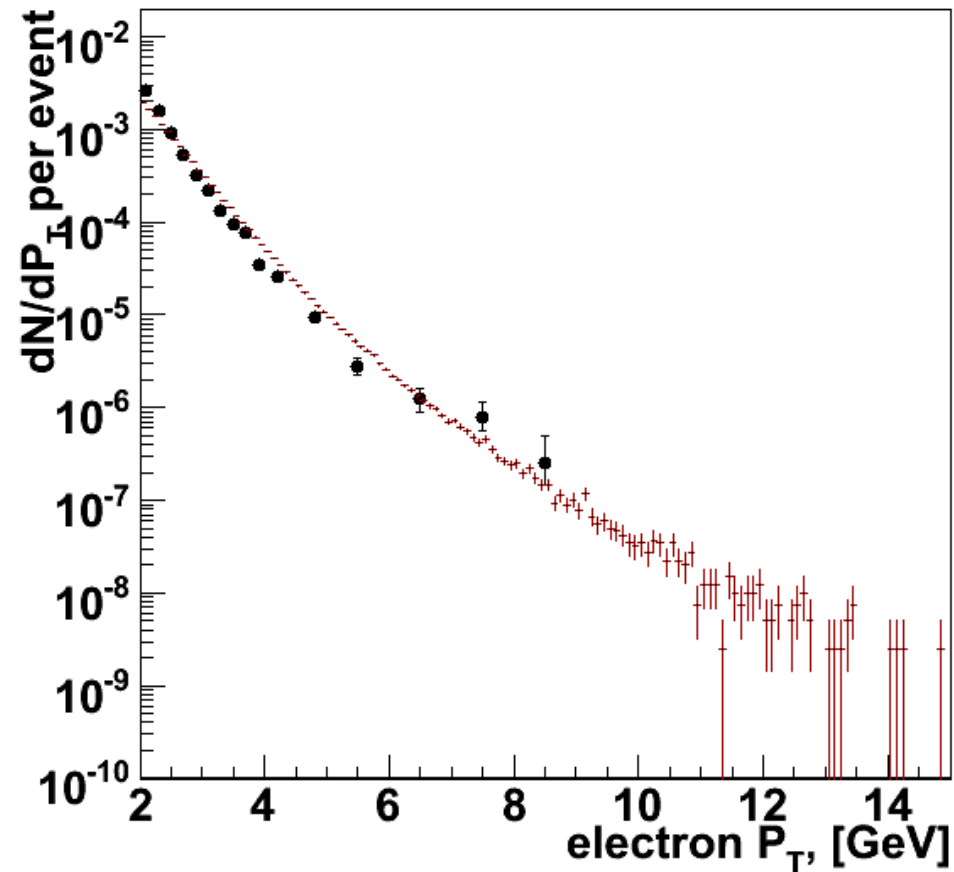
3. Use this normalization to normalize the Upsilon background invariant mass distribution.
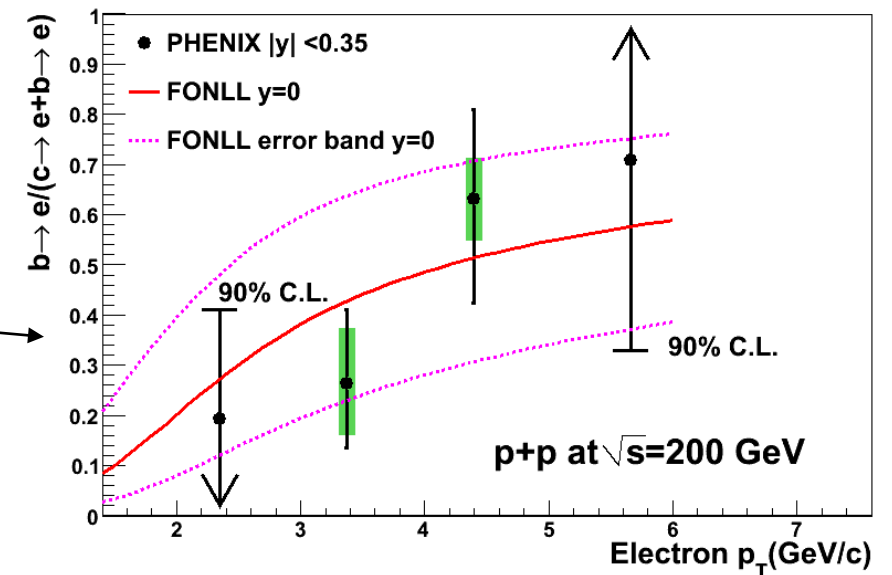
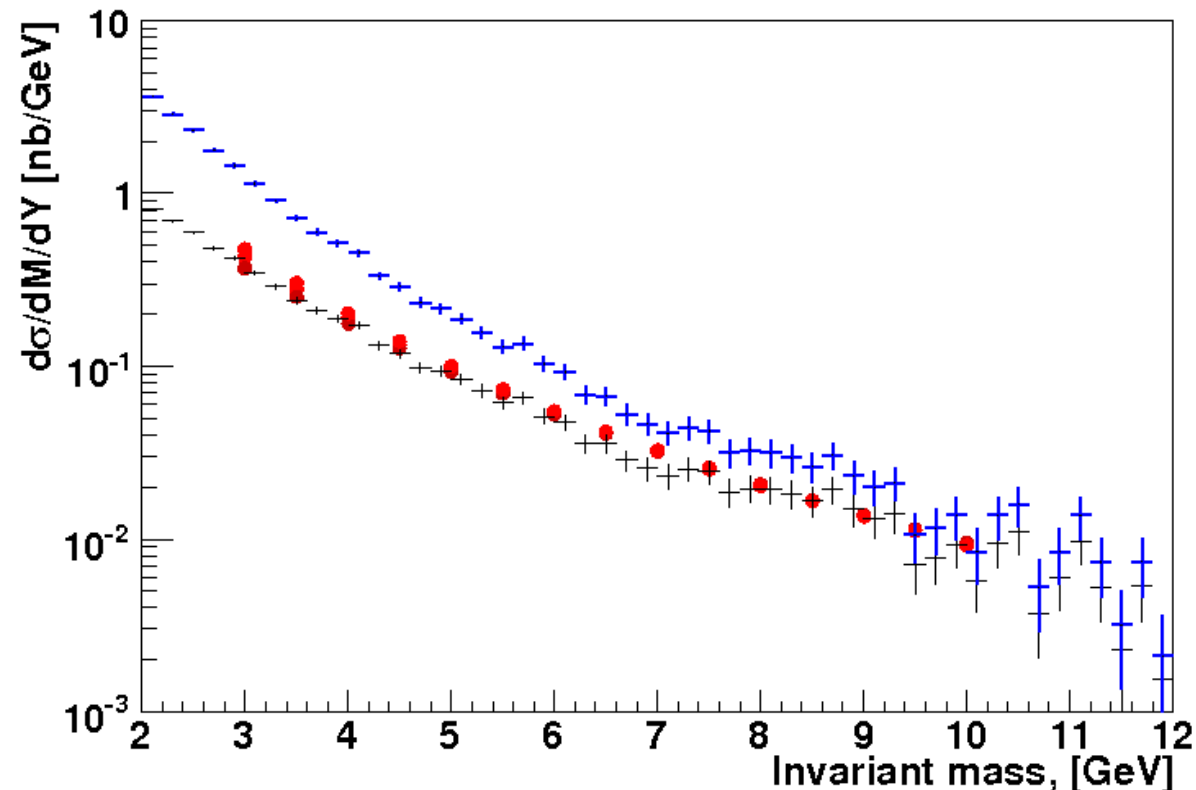# Normalization of charm/bottom

Black points: measured HF electrons in central Au+Au separated into charm and bottom.
Red: PYTHIA electrons from charm, blue: PYTHIA electrons from bottom

Correlated background from Drell-Yan

Calculated using tuned PYTHIA and scaled up to central Au+Au by N_{COLL}.
Normalization from W.Vogelsang prediction (private communication)

Blue: Tuned PYTHIA
Red: W.Vogelsang's prediction
Black: re-normalized PYTHIA

At ~10GeV all points agree anyway.

Combinatorial background calculation

Take fits to hadron spectra in p+p, scale by N_{COLL} and R_{AA}, correct by hadron rejection.
This gives us dN/dp_T per events for mis-identified hadrons (fake electrons) in central Au+Au collisions.

1. Pion spectra from measured pi-zero spectra in p+p (ppg063)
Other hadron spectra: shape from m_T scaling of pi-zeros, absolute normalization
from ppg030 (see next slide).

2. Scale by N_{COLL} (955) and measured R_{AA} (see backup) and hadron rejection (slide 9).
This gives us dN/dp_T for mis-identified hadrons (fake electrons) in central Au+Au events.

3. For each event, generate number of fake electrons (smeared Poisson), for each fake
electron generate kinematics (p_T, etc.). Calculate invariant mass.

4. Do the same for fake electron / heavy flavor combinations.

Combinatorial background: hadron rejection

Single hadrons embedded in central (0-4.4fm) Hijing events and reconstructed.
Jin's code branch: *RefDesign-2016Rescoping-Embed*
https://github.com/blackcathj/macros/tree/RefDesign-2016Rescoping-Embed/macros/g4simulations

10k electrons and 100k pions/kaons/protons/anti-protons in 1k Au+Au Hijing events in
/sphenix/sim/sim01/production/2016-07-12/sHijing/spacal2d/
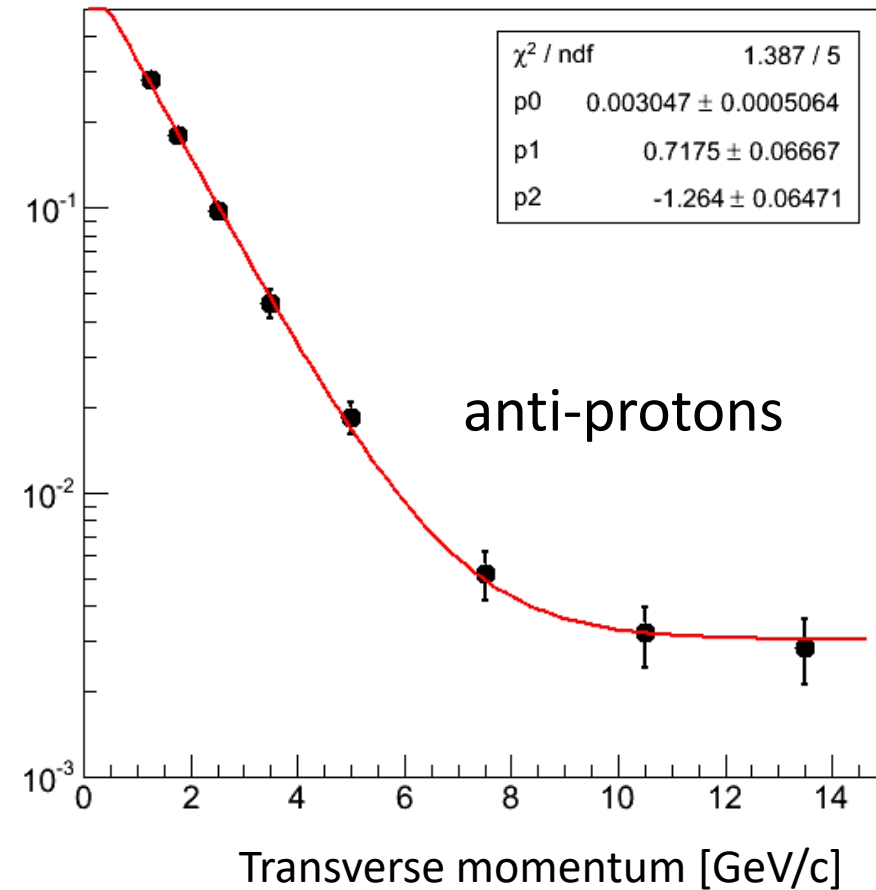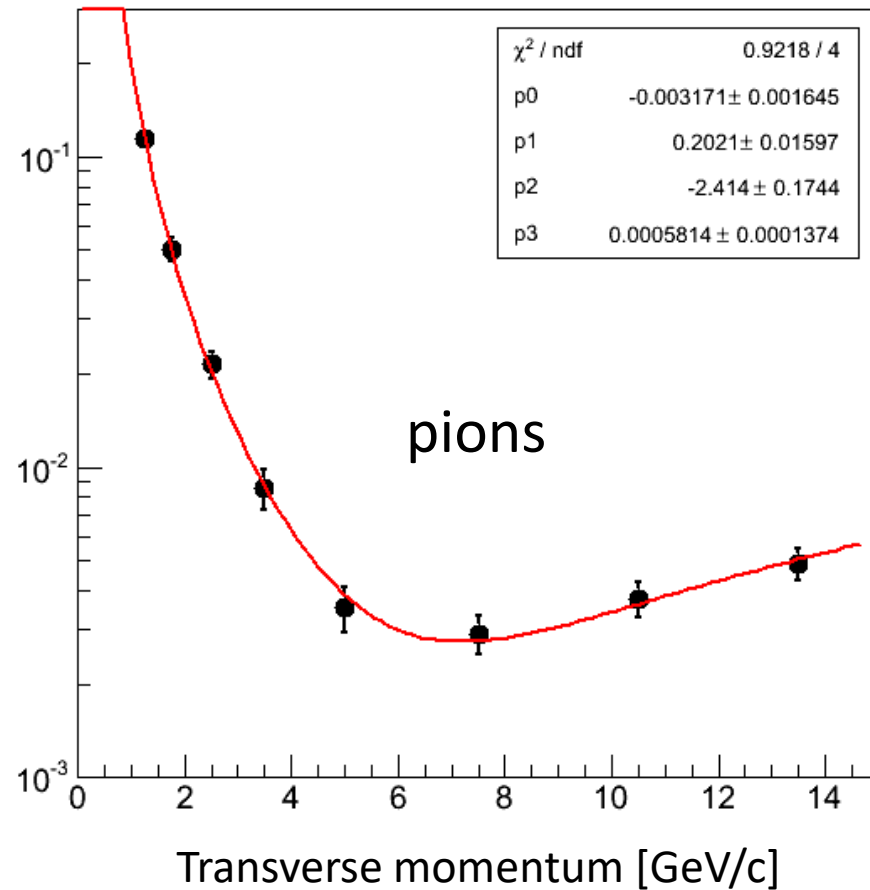Each Hijing event used 100 times.

Use E_{CEMC}/P to reject hadrons. Additional E_{HCALIN}/E_{CEMC} cut does not help (see backup).
E_{CEMC} and E_{HCALIN} in 3x3 cells.

Electron identification efficiency: 90% and 70%.

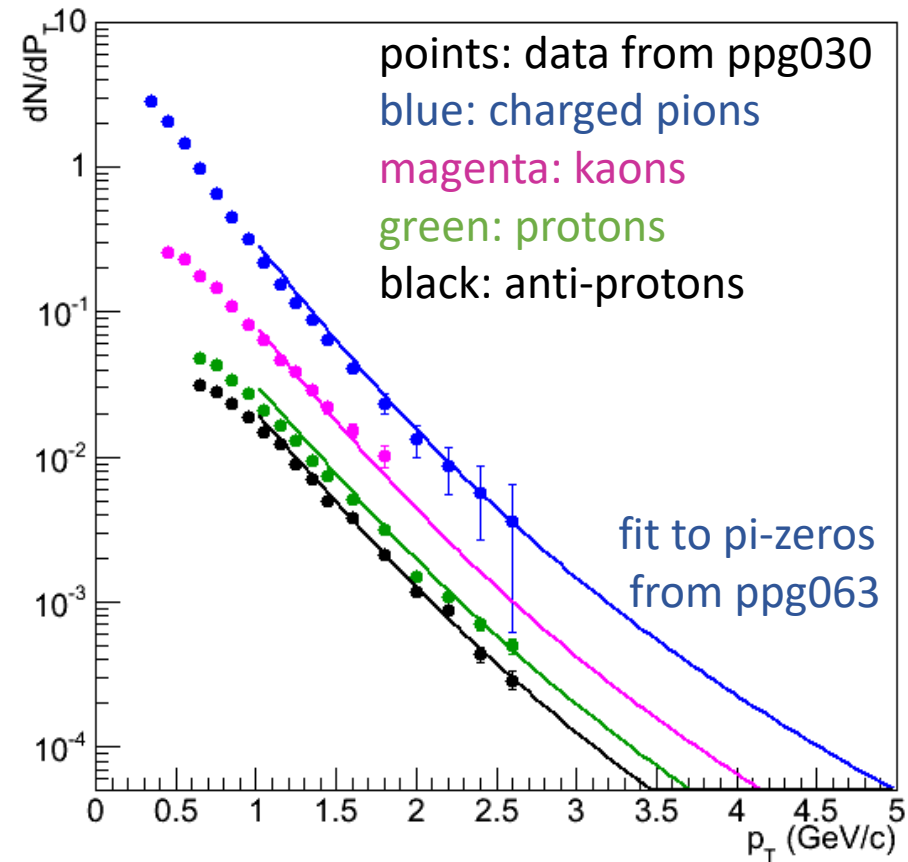# Inverse hadron rejection factors

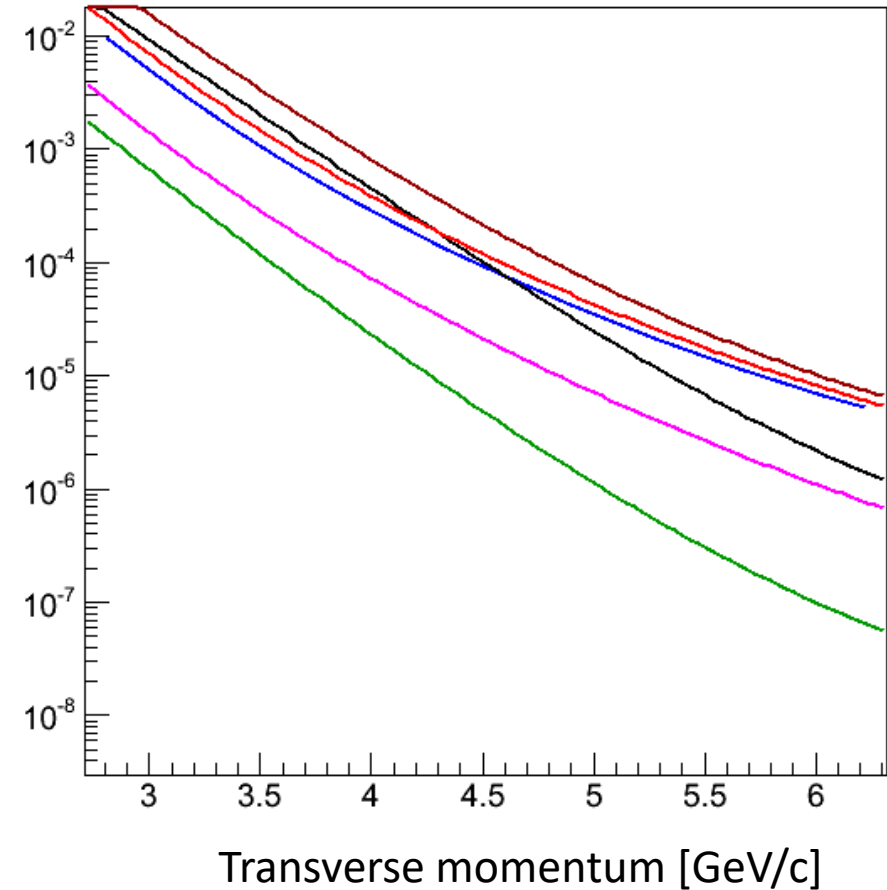Plots for 90% eID efficiency. For 70% eID efficiency rejection is ~2.5 times better.

pions

anti-protons

Transverse momentum [GeV/c]

Transverse momentum [GeV/c]

Hadron spectra normalization

measured hadron spectra in p+p

fake electron spectra in Au+Au

points: data from ppg030
blue: charged pions
magenta: kaons
green: protons
black: anti-protons

fit to pi-zeros
from ppg063

N_{COLL}
R_{AA}
hadron
rejection

Transverse momentum [GeV/c]

Backgrounds

eID efficiency 90%

eID efficiency 70%
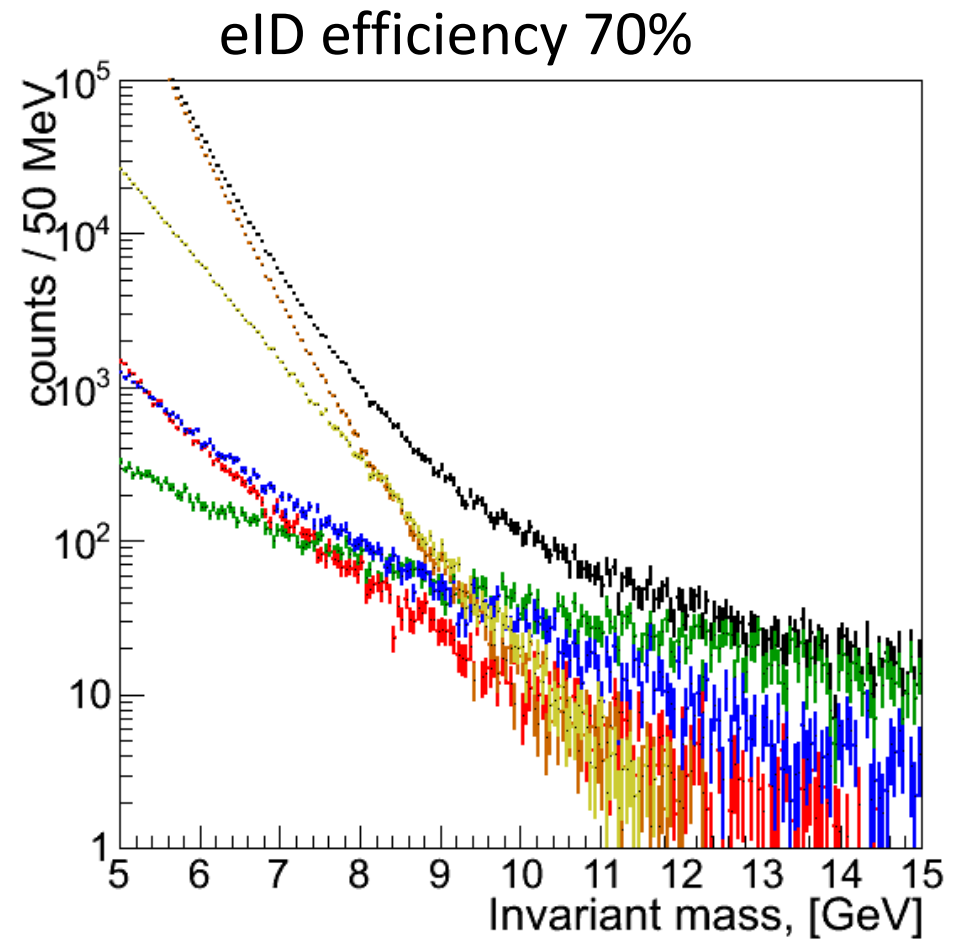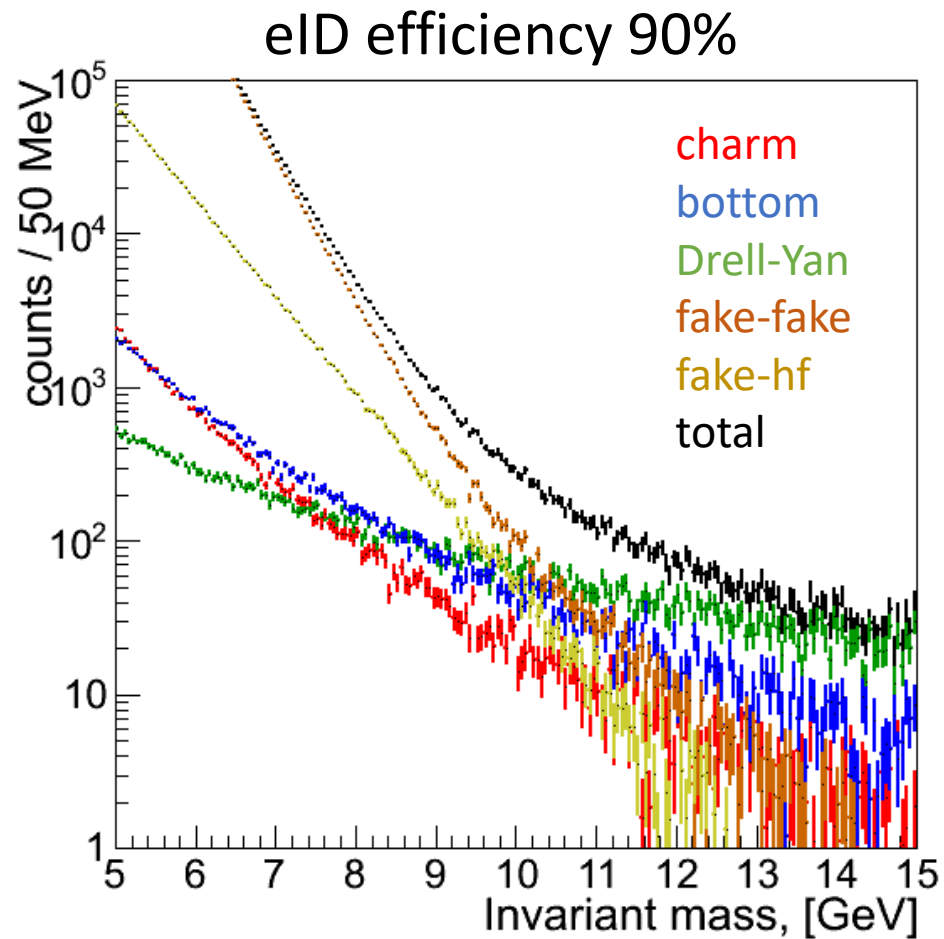
Upsilon Yield

Upsilon acceptance was calculated using tuned PYTHIA.
Integrated over p_T acceptance = 0.307.
Upsilon cross-section at mid-rapidity $d\sigma/dy$ = 5nb ± 1.8nb (PHENIX measurement).
According to PYTHIA 36.55% of all Upsilons are produced in one unit of rapidity
at mid-rapidity, so, total Upsilon cross-section $\sigma[Y(1S+2S+3S]$ = 13.7nb ± 5nb
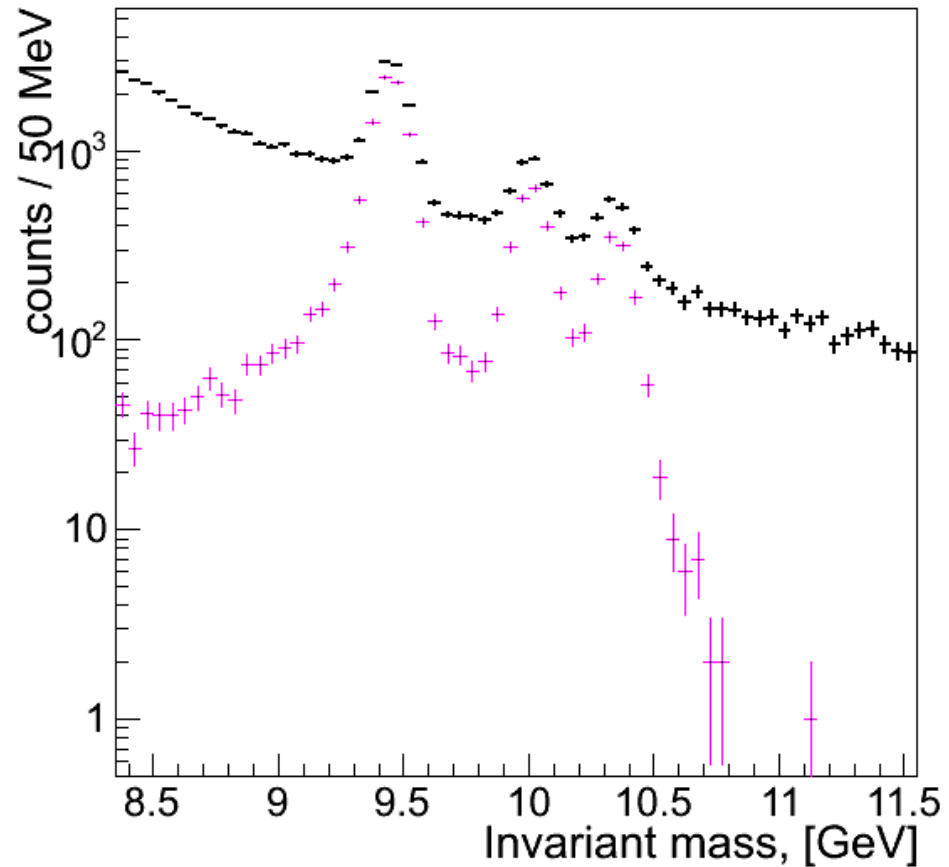Upsilon yield ratios: 0.712 : 0.185 : 0.103
NCOLL = 955, RAA = 1.0
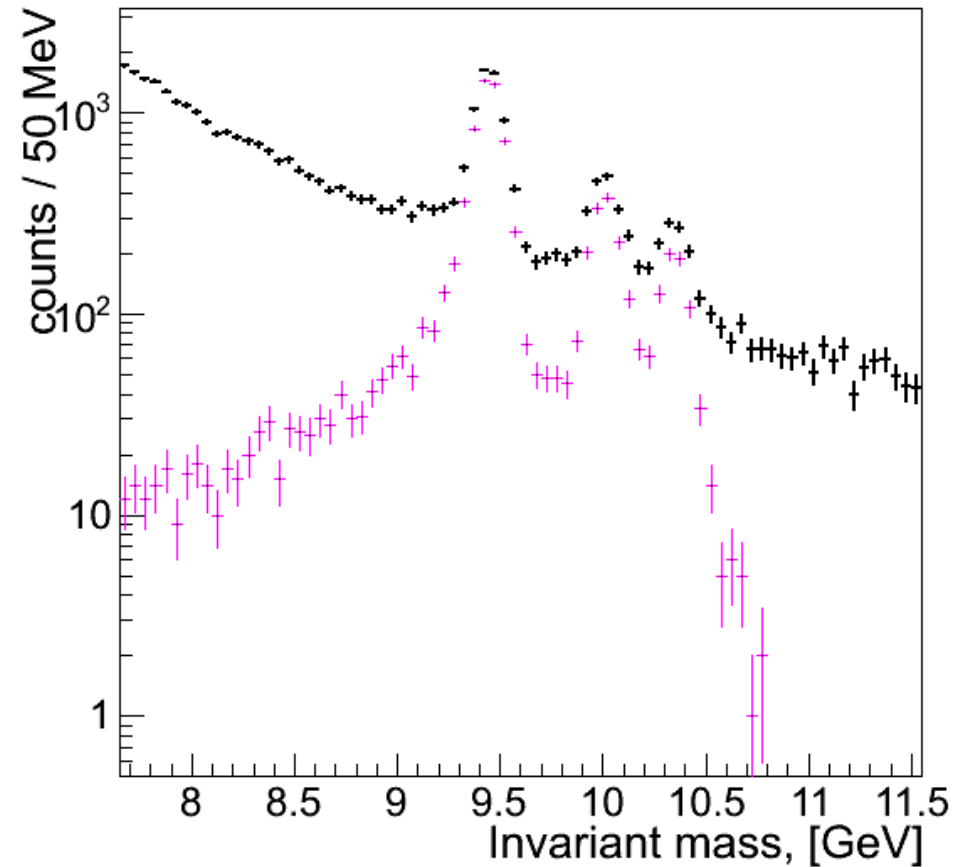Total number of reconstructed Upsilons in 10B 0-10% central Au+Au events = 22.9k

Upsilons generated by *PHG4ParticleGeneratorVectorMeson* were embedded
in central (0-4.4fm) Au+Au Hijing events and reconstructed.

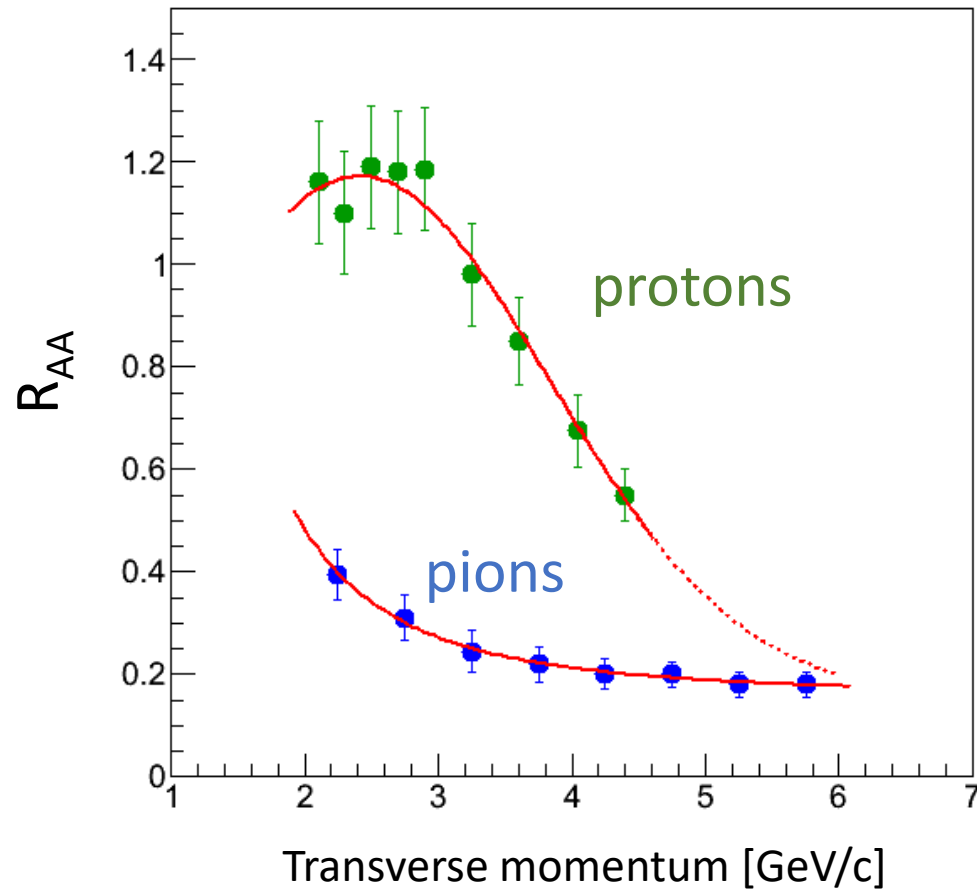# Background plus Signal

eID efficiency 90%

eID efficiency 70%
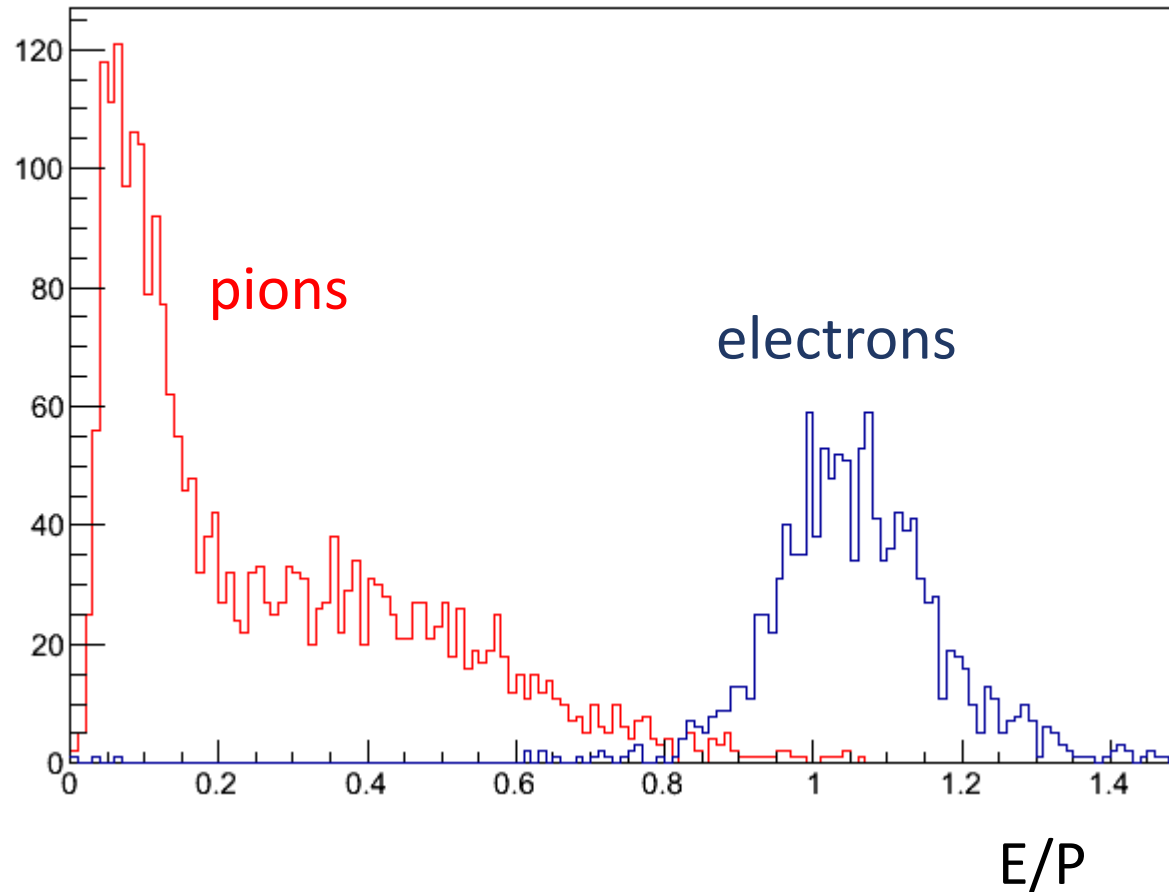

Upsilon mass resolution ~85MeV

Backup Slides

R$_{AA}$ (ppg146)
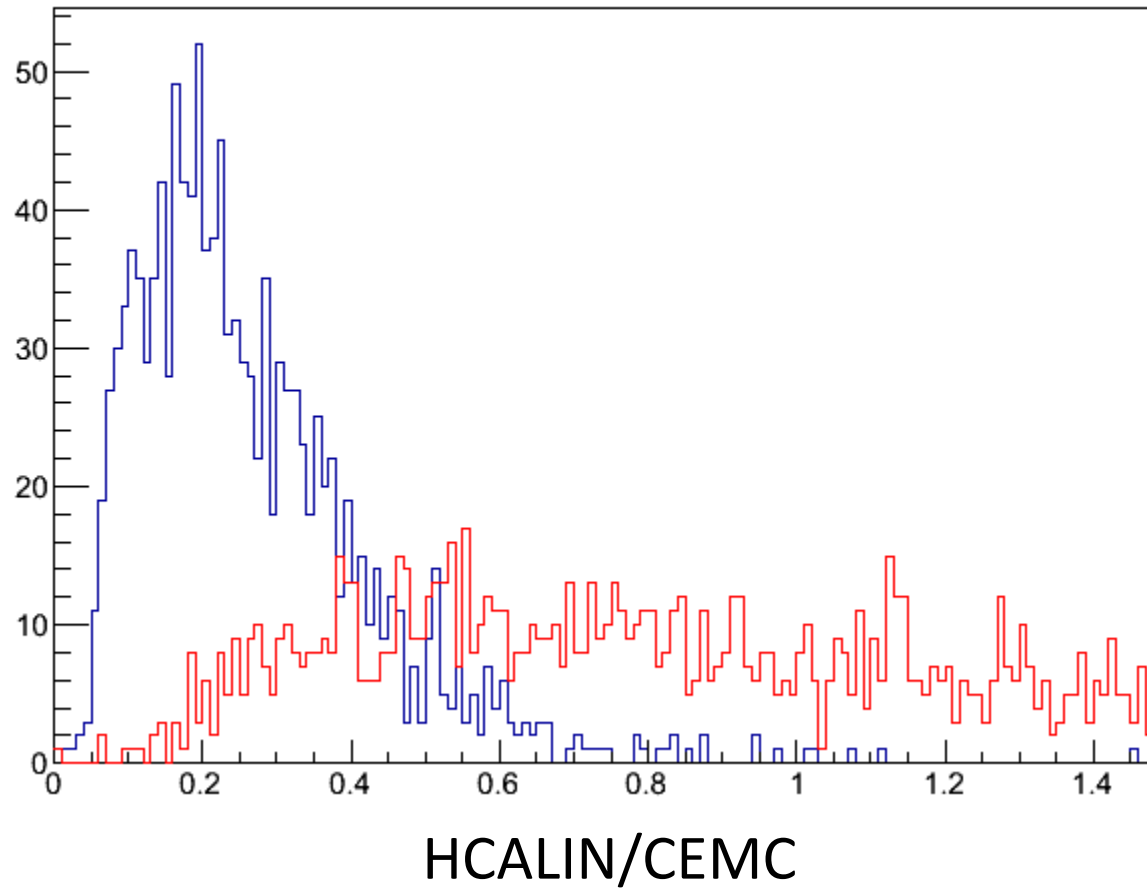

anti-protons same as protons
kaons same as pions

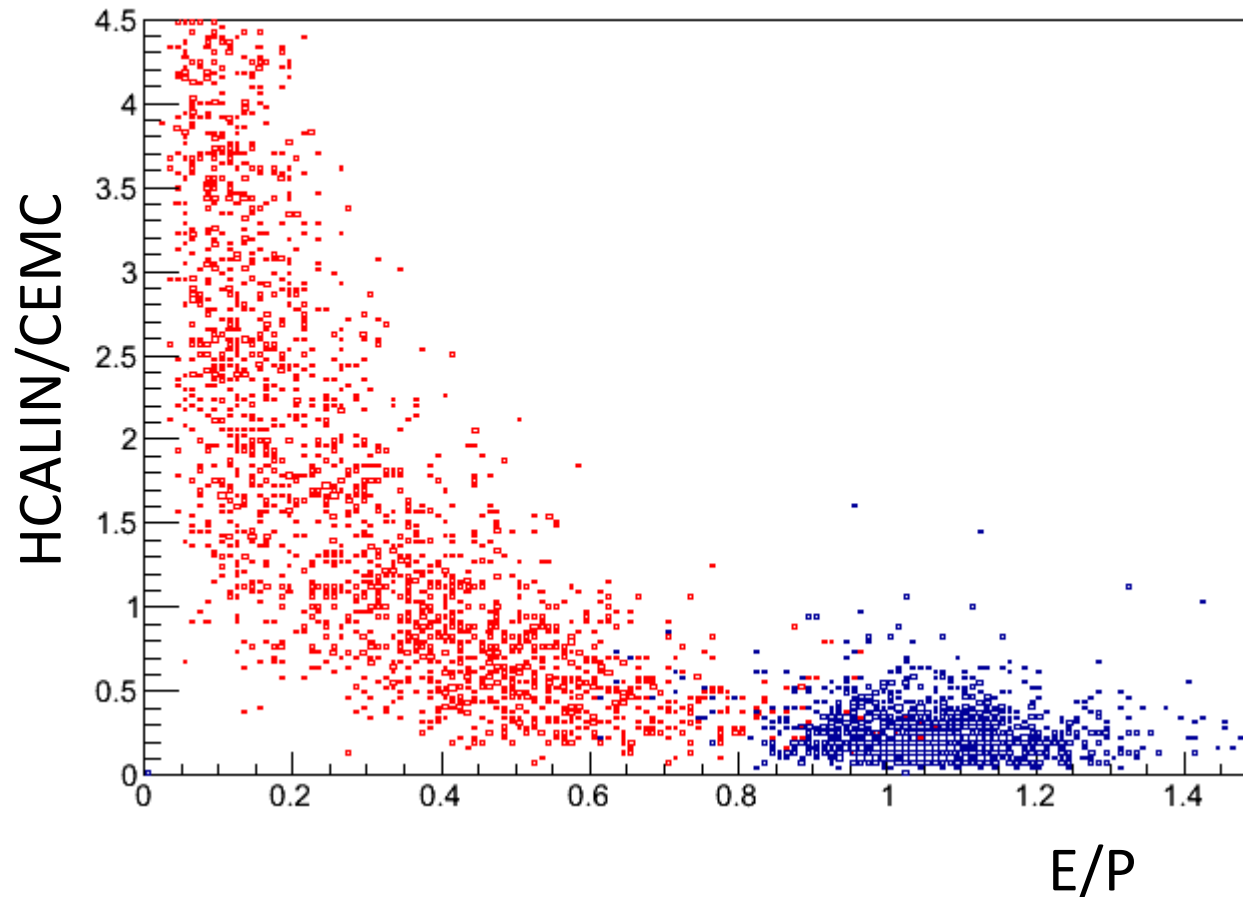# Pion rejection using E/P in CEMC

Example for $4 < p_T < 6$ GeV/c

CEMC energy in 3x3 cell

pions

electrons

E/P

Pion rejection using HCALIN / CEMC

Both CEMC and HCALIN energy in 3x3 cell

HCALIN/CEMC

HCALIN/CEMC vs E/P in CEMC

After applying E/P cut adding HCALIN/CEMC cut does not help.

Typical 90% electron efficiency cut is E/P>0.9